ELECTRONIC CIRCUIT FOR CONTACTLESS TAG, AND CONTACTLESS TAG

BACKGROUND OF THE INVENTION

Technical Field of the Invention

[0001]

The present invention relates to a contactless tag and also relates to an electronic circuit for the contactless tag used in a Radio Frequency IDentification (RFID) tag or a RFID card.

Description of the Related Art

[0002]

An electronic circuit for a contactless tag includes an antenna that receives data for communication with a reader/writer. In a conventional electronic circuit, a signal received by an antenna is rectified, thereby forming a power supply.

[0003]

For installation of a memory or a display unit, it is conceivable to use a secondary battery that can be charged within seconds. The charging time of the secondary battery has a high charging rate of 1:1. The current of the battery capacity is given by the following equation:

$$\text{Charging Time} \cong 1\ \text{mA/h} \div 1\ \text{mA} = 1\ \text{hour}$$

where the secondary battery capacity = 3 V, 1 mA/h, and the charging current = 1 mA. A problem occurs in that it takes a long time to fully charge the battery.

[0004]

The present invention has been made in view of this problem with conventional electronic circuit, and it is an advantage of the present invention to

provide an electronic circuit for a contactless tag that can be fully charged in a short period of time, and to provide a contactless tag.

SUMMARY OF THE INVENTION

[0005]

In order to overcome this problem, the present invention employs the following. According to an embodiment of the present invention, an electronic circuit for a contactless tag includes a transceiving device for data communication with a reader/writer. The transceiving device includes an antenna coil. The electronic circuit includes a rectifying device that rectifies an induced electromotive force caused by bringing the antenna coil into close proximity to the reader/writer to generate a rectified voltage. A secondary battery is also provided. A charging/discharging circuit is charged according to the rectified voltage and discharges the secondary battery.

[0006]

According to an embodiment of the present invention, the charging/discharging circuit includes a capacitor that stores a charge according to the rectified voltage. A resistor acts as a time-constant resistor, through which the capacitor supplies a discharge voltage to the secondary battery so as to charge the secondary battery. A diode prevents the charge charged in the capacitor from flowing to a portion other than the secondary battery.

[0007]

Also, according to an embodiment of the present invention, the capacitor is a device serving as an electric double-layer capacitor or a capacitor whose internal resistance is much smaller than that of the secondary battery and whose electrostatic capacitance is large. The diode is defined as a first diode and the

capacitor is defined as a first capacitor. The charging/discharging circuit further includes a second diode connected in series to the first diode and a second capacitor connected in parallel to the first capacitor between the first diode and the second diode. The second capacitor has a smaller capacitance than the first capacitor.

[0008]

Further, according to an embodiment of the present invention, an existing antenna coil is brought into close proximity to a reader/writer to cause an induced electromotive force. The induced electromotive force is rectified to generate a rectified voltage, based on that charging/discharging circuit that is charged. Then, the charging/discharging circuit performs discharging, and the secondary battery is thus charged.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a block diagram showing the structure of an electronic circuit for a contactless tag according to a first embodiment of the present invention.

[0010]

Fig. 2 is a block diagram showing the structure of a charging/discharging circuit and a secondary battery shown in Fig. 1.

[0011]

Fig. 3(a) is a charge-discharge characteristic diagram of a capacitor of the charging/discharging circuit of the contactless-tag electronic circuit shown in Fig. 1. Fig. 3(b) is a charge characteristic diagram of the secondary battery of the contactless-tag electronic circuit shown in Fig. 1.

[0012]

Fig. 4 is a block diagram showing the structure of a charging/discharging circuit of an electronic circuit for a contactless tag according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013]

Embodiments of the present invention will now be described with reference to the drawings.

First Embodiment: Structure

[0014]

An electronic circuit for a contactless tag according to a first embodiment of the present invention will be described with reference to Figs. 1 and 2.

[0015]

As shown in Fig. 1, the contactless-tag electronic circuit of the first embodiment includes a transceiving device for data communication with a reader/writer. The transceiving device includes a resonance circuit 13 serving as resonance device having an antenna coil L, a rectification circuit 15 serving as rectifying device for rectifying an induced electromotive force caused by bringing the antenna coil L into close proximity to the reader/writer to generate a rectified voltage Vdd. A secondary battery B is also provided. A charging/discharging circuit 17 serves as a charging/discharging means that is charged according to the rectified voltage Vdd and that discharges the secondary battery B. The secondary battery B is of the paper battery type, and has an internal resistor rb.

[0016]

The contactless-tag electronic circuit of the first embodiment, which is

suitable for use in a Radio Frequency IDentification (RFID) tag or a RFID card, further includes an RFID control circuit 19 having a detection circuit that detects a drop in the rectified voltage Vdd, and an electrophoretic display unit 21. The electrophoretic display unit 21 has a writing voltage of 3 V (internal boosted voltage), a current of 10 μ A, and a display holding time of about several minutes.

[0017]

Referring to Fig. 2, the charging/discharging circuit 17 includes a capacitor C, which is an electric double-layer capacitor, charged by storing a charge according to the rectified voltage Vdd supplied via a diode D of the rectification circuit 15. A resistor R acts as a time-constant resistor, through which the capacitor C supplies a discharge voltage to the secondary battery B so as to charge the secondary battery B. The capacitor C has an internal resistor rc (30 Ω).

First Embodiment: Operation

[0018]

The operation of the electronic circuit of the first embodiment will now be described with reference to Figs. 1 through 3.

[0019]

The induced electromotive force of an input voltage received by the antenna coil L of the resonance circuit 13 serving as a resonance means of the contactless-tag electronic circuit of the first embodiment is rectified by the rectification circuit 15 to generate a rectified voltage Vdd.

[0020]

Referring to Figs. 2 and 3, the diode D of the charging/discharging circuit 17 applies the rectified voltage Vdd (for example, 5 V) to the capacitor C so as to prevent the current from flowing back. At this time, a current flows in the

internal resistor rc (30 Ω), thus causing a charge to be stored in the capacitor C and to be charged. The capacitor C is charged until a time t1 (for about five seconds) according to the rectified voltage Vdd.

[0021]

When the input voltage shown in Fig. 2, that is, the rectified voltage Vdd, fails, the charge stored in the capacitor C causes a discharge voltage to be supplied to the secondary battery B via the internal resistor rc, the resistor R, and the internal resistor rb for a period of time from t1 to t2, and the secondary battery B is therefore charged.

[0022]

Referring to Fig. 2, simple charge/discharge calculation for the capacitor C is carried out, where the diode forward voltage Vf is ignored.

[0023]

Charge: The charge Q charged from 0 V to 5 V is given by the following equation:

$$0.05 \text{ F} \times 5 \text{ V} = 0.25 \text{ (Q)}$$

Assuming that 0.25 (Q) is charged in the time t1 (five seconds), the current I is given by the following equation:

$$0.25 \text{ (Q)} \div 5 \text{ sec} = 50 \text{ mA}$$

Discharge: The charge Q necessary for a discharge from 5 V to 3.3 V is given by the following equation:

$$\text{Charge Q} = 0.05 \text{ F} \times (5 \text{ V} - 3.3 \text{ V}) = 0.085 \text{ (coulomb)}$$

The current I required for discharging 0.085 (coulomb) in 15 minutes is given by the following equation:

$$\text{Current I} = 0.085 \text{ (coulomb)} \div 900 \text{ sec} = 94.4\ \mu\text{A}$$

The current limiting resistance R for 94.4 μA is given by the following equation:

$$\text{Current Limiting Resistance } R = (5\text{ V} - 3.3\text{ V}) \div 94.4\ \mu\text{A} = 18\ \text{k}\Omega$$

Since the current I is the mean current, the current limiting resistance R is actually half, or 9 kΩ.

[0024]

As shown in Fig. 3(a), charging/discharging from the capacitor C is repeated about four times, and the secondary battery B is charged in the manner shown in Fig. 3(b).

Second Embodiment: Structure

[0025]

A charging/discharging circuit 17-1 of an electronic circuit for a contactless tag according to a second embodiment of the present invention will now be described with reference to Fig. 4.

[0026]

The charging/discharging circuit 17-1 shown in Fig. 4 includes a first diode D1, a second diode D2 connected in series to the first diode D1, a first capacitor C1, which is an electric double-layer capacitor, having an internal resistor rc1, and a second capacitor C2 connected in parallel to the first capacitor C1, which is also an electric double-layer capacitor, having an internal resistor rc2. The second capacitor C2 has a smaller capacitance than the first capacitor C1. The second capacitor C2 has a smaller capacitance than the capacitor C of the first embodiment.

[0027]

The second capacitor C2 of a small capacitance is connected in parallel between the secondary battery B and the first capacitor C1. Thus, even when the first capacitor C1 cannot be fully charged because the supply time of the induced electromotive force caused by bringing the tag into close proximity to the reader/writer is short, a charge is stored in the second capacitor C2, and the stored charge is discharged to the secondary battery B to charge the secondary battery B.

[0028]

However, in the second embodiment, the number of times of charging/discharging must be greater than that in the first embodiment. This is because the capacitance of the second capacitor C2 is small and has a small amount of charging, and therefore the amount of discharging for the secondary battery B per charge/discharge is small.

Second Embodiment: Operation

[0029]

Referring to Fig. 4, when a rectified voltage Vdd is applied to the input, it is supplied via the diode D1 and the internal resistor rc1 of the first capacitor C1 so as to charge the first capacitor C1. It is also supplied via the diode D2 and the internal resistor rc2 of the second capacitor C2 so as to charge the second capacitor C2. The internal resistor rc1 is greater than the internal resistor rc2. Thus, the time required for storing a charge in the first capacitor C1 when it is charged is longer than that of the second capacitor C2.

[0030]

The charge stored in the second capacitor C2 is faster discharged to the secondary battery B via the resistor R and the internal resistor rb than that in

the first capacitor C1. Therefore, the secondary battery B is charged.

First and Second Embodiments: Advantages

[0031]

As described above, according to the contactless-tag electronic circuit of the first and second embodiments, the charging/discharging circuit 17 or 17-1 based on the induced electromotive force caused by bringing the antenna coil L into close proximity to a reader/writer allows the secondary battery B to be fully charged in a short period of time. Particularly, according to the second embodiment, advantageously, the additional use of a second capacitor with a small capacitance supports the usage in which the supply time of the induced electromotive force is short, compared to the first embodiment.

Modifications

[0032]

In the first and second embodiments, an electric double-layer capacitor is used as each of the capacitors C, C1, and C2. However, the present invention is not limited thereto. As an alternative to the electric double-layer capacitor, a device serving as a capacitor whose internal capacitance is much smaller than that of the secondary battery B and whose electrostatic resistance is large may be used.